FLORA W. PATTERSON.

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AGRICULTURAL EXPERIMENT STATION

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WHEAT

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By. G. Roberts.

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Kentucky Agricultural Experiment Station

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LEXINGTON, KENTUCKY

BULLETIN NO. 155.

WHEAT.

By GEORGE ROBERTS AND E. J. KINNEY.

1. Variety Tests.

Report is made in this Bulletin of the results of tests of varieties of wheat from 1905 to 1911 inclusive, with the exception of the year 1908.

It will be noted that many of the varieties were dropped from the list in 1911, some because they were low in yield, some because of poor quality and some for both reasons, while others were dropped on account of weak straw. If a variety is to prove itself valuable, five years ought to be sufficient time for it to give some indications of value. On the other hand it is not always possible in five or six years to determine which is the best of several close competitors. Some years one variety will stand first in yield, while in other years it will drop back several places. This may be due in part to seasonal conditions, but it is perhaps more generally due to variations in the fertility of the soil in which the varieties are grown.

Up to the present time the varieties have not been grown in duplicate series on account of the lack of ground to accommodate such a large number of varieties.

The wheats have been grown on different plots of ground each year, in the regular rotations of the farm, usually following tobacco or soy beans. Fertilizers have not been used, but great care has been taken to prepare the seed bed properly. The soil of the Experiment Station farm is not above that of the surrounding country in native fertility, so the results fairly represent what may be accomplished in wheat production on this type of soil, provided good seed is used, the wheat grown in proper rotation, and the seed bed properly prepared.

Table No. 1 gives the yields per acre by years with the average for the period grown.

TABLE NO I.

Variety	Yields Per Acre in Bushels of 60 Pounds						No. Years Grown.	Average Yield Per Acre
	1905	1906	1907	1909	1910	1911		
Jersey Fultz	36.0	29.3	28.2	38.0	39.0	36.7	6	34.5
Extra Early Oakley	33.0	24.7	25.0	37.3	38.3	35.5	6	32 3
Beechwood Hybrid	40.0	26.7	21.0	35.3	39.7	30.0	6	32.1
Kansas Mortgage Lifter	36.0	26.7	29.2	35 0	32 0	34.0	6	32.1
Harvest King	32.0	27.2	22.5	40.0	38.0	31.7	6	31.9
Fulcaster	38.2	28.3	22 3	33.8	33.0	36.0	6	31.9
Gold Coin	35.2	28.7	19.8	38.0	36.5	32.7	6	31.8
Improved Rice	34.0	27.0	25.0	33.2	41.7	29.0	6	31.6
B—383	34.0	20.5	25.4	40.0	33.2	36.0	6	31.5
Turkey Red	33 3	26.5	18.8	35.3	37.5	37.3	6	31.4
Lancaster Red	30.5	28.3	26.7	35.0	33.8	33.5	6	31.3
Bearded Pootung	34.3	23.7	19.6	33.0	36.0	37.0	6	30.6
Canadian Hybrid	33.7	26.2	22.1	30.2	42.2	27.7	6	30.3
Blue Stem	36.0	26.7	22.5	32.6	35.2	27.3	6	30.0
Indian Swamp	33.7	27.0	15.4	34.0	37.0	32.5	6	29.9
Rudy	33.3	25.2	20.8	34.5	35.2	27.3	6	29.4
New Columbia	31.7	17.7	15.8	28.6	41.5	29.0	6	27.4
B—382	37.8	21.7	16.3	13.8	26.8	.....	5	23.3
B—377	38.0	25.5	24.6	24.3	29.7	.....	5	28.4
Fultz	36.7	26.7	23.3	17.5	34.0	.....	5	27.6
Pootung	32.2	20.0	17.1	17.0	34.8	.....	5	24.2
B—309	37.3	22.5	19.6	28.6	38.7	.....	5	29 3
Harvest Queen	30.3	32.2	19.0	29.7	38 7	.....	5	30.0
9125	23.3	26 7	17.9	22.0	23.7	.....	5	22.7
11606	31.3	33.0	17.9	25.8	33.0	.....	5	28 2
Pearl Prolific	32.7	28.3	15.6	28.7	27.8	.....	5	26.6
Early Ripe	.....	.....	22.3	35.5	39.0	29.7	4	31.6
Dawson's Golden Chaff	36 7	26 3	9.9	.....	39.0	.....	4	28.0
Red Wonder	.....	.....	23.1	35.2	30.2	34.0	4	30.6
Hungarian	34.0	26.0	.....	27.2	40.3	.....	4	31.9
9358	25.7	.....	17.7	21.0	17.2	.....	4	20.4
Rochester	.....	....	22.1	38.0	31.7	35.0	4	31.7
Deitz	.....	.....	24.0	37.0	31.0	.....	3	30.7
Valley	.....	.....	24.4	35.3	31.0	.....	3	30.2
Lebanon	.....	.....	24.0	36.5	31.8	....	3	30.8
Hickman	.....	.....	23.1	36.7	26.7	.....	3	28.8
Lehigh	.....	.....	19.2	36.3	28.3	.....	3	27.9
Red Wave	.....	.....	.....	36.0	42.7	32.3	3	37.0
Winter King	.....	.....	18.8	29.5	26 8	.....	3	25.0
Miracle	....	.....	.....	.....	27.3	37.3	2	32.3
Silver Queen	.....	.....	.....	28.0	37.3	.....	2	32.7
Acme Bred	.....	.....	.....	. ...	. ...	32.0	1	32.0

*Note—Those varieties designated by number were obtained from the United States Department of Agriculture.

TABLE NO. II.

VARIETY	Average Yield Per Acre	Average Weight Per Bushel	Average Milling Quality	Bearded or Smooth	No Years Grown
Jersey Fultz	34.5	60 0	93 7	S	6
Extra Early Oakley	32.3	58.7	92.2	S S	6
Beechwood Hybrid	32.1	58.7	94.5	S S	6
Kansas Mortgage Lifter	32.1	59.9	95 0	B S	6
Harvest King	31.9	59.7	94.2	S S	6
Fulcaster	31.9	60.4	95.5	B	6
Gold Coin	31.8	58 5	88.7	S S	6
Improved Rice	31.6	59.4	93.0	S S	6
B—383	31.5	60.0	93.0	S S	6
Turkey Red	31.4	60 6	92.2	B	6
Lancaster Red	31.3	60.4	94.2	B	6
Bearded Pootung	30.6	59.9	95.5	B	6
Canadian Hybrid	30.3	60.0	94.2	S	6
Blue Stem	30.0	60.2	91.8	S S	6
Indiana Swamp	29.9	59.7	93.5	B	6
Rudy	29.4	58.9	93.7	B	6
New Columbia	27 4	58.6	93.2	S S	6
B—382	23.3	59.1	94.0	B	5
B—377	28.4	59.0	93.3	B	5
Fultz	27.6	59.9	94.3	S	5
Pootung	24 2	59.7	94.0	S	5
B—309	29 3	59.9	92.7	B	5
Harvest Queen	30.0	56 7	85.3	S	5
9125	22 7	58.7	89.0	B	5
11606	28.2	58.6	91.0	B	5
Pearl Prolific	26.6	58.1	95.0	S	5
Early Ripe	31.6	57.9	90.0	S S	4
Dawson's Golden Chaff	28.0	55.2	85.7	S S	4
Red Wonder	30.6	59.3	95 5	B	4
Hungarian	31.9	59.9	93 7	B	4
9358	20.4	58.1	85 0	B	4
Rochester	31.7	58 6	92.5	S	4
Deitz	30.7	58.0	93.0	B	3
Valley	30.2	57.3	91.0	B	3
Lebanon	30 8	57.8	93.0	B	3
Hickman	28.8	56.0	92.0	S	3
Lehigh	27.9	57.3	90.0	B	3
Red Wave	37.0	57.3	90.0	S	3
Winter King	25.0	57.9	92 0	S	3
Miracle	32.3	60.0	95.0	B	2
Silver Queen	32.7	56.9	88.0	B	2
Acme Bred	32.0	60.0	90 0	B	1

Table No. 2 gives the average yield, the average weight per bushel, average milling quality, the number of years grown and whether the wheat is smooth or bearded. The milling quality was estimated by Mr. W. W. Patterson, of the Lexington Roller Mills, and is not based upon actual milling and baking tests, as the Experiment Station is not provided with facilities for this work.

It will be seen by examining the foregoing tables that there are some varieties that have shown themselves good yielders of high quality grain. The most conspicuous of these is Jersey Fultz with a record of an average yield of 34.5 bushels per year for six years, an average weight per bushel of 60 pounds, and an average milling quality of 93.7. We have no hesitancy in recommending this as the best variety we have tried for the region about Lexington and similar regions. It is a smooth wheat, with a good straw. The only objection that can be found to it is that occasionally it will lodge a little on very rich land in case of high winds and wet weather. But almost any variety is liable to do this.

Extra Early Oakley is a good variety for strong land. It has a velvet chaff and is a smooth wheat with a good straw. However, velvet chaff wheats usually sell a little lower than other wheats in the large markets.

Two other smooth wheats that deserve special mention are Harvest King and B-383. They have splendid straw, seldom lodging under the most unfavorable conditions. While they rank fifth and ninth respectively in yield, the variation from other varieties, except Jersey Fultz, is so small as to be insignificant when their good qualities are considered. Harvest King is a standard variety. B-383 is a hybrid wheat furnished the Station by the United States Department of Agriculture and there is none in the State except about 100 bushels at the Experiment Station, which will be distributed and grown under the supervision of the Station. In this way it is hoped to introduce it in the State if it proves a success away from the Station farm. It will be given a name before distributing it.

Among the bearded wheats we would especially recommend Kansas Mortgage Lifter, Fulcaster and Lancaster Red.

In many sections of the State there is a prejudice against the growing of bearded wheat. It seems, however, that there is little ground for this prejudice now when the wheat is handled almost entirely by machinery, it hardly being touched by hand from the time it is harvested by the self-binder to the time it is threshed by the self-feeding separator. It is generally supposed that the bearded wheats have a weak straw, and as a rule they do have a weaker straw than the smooth wheats, yet some of them, such as the ones named above, have a fairly good straw. One bearded variety of good quality and yield that we have discarded on account of poor straw is Hungarian.

The objection that bearded wheats damage more easily in wet weather seems hardly sufficient reason for discriminating against them.

One of the newer varieties that gives good promise is Miracle, a bearded wheat which is quite hard, of excellent quality, a good yielder, and possesses a good straw. It has been tried only two years. It was the best yielder in 1911 and ranked among the best in milling quality. It is a wheat with especially good stooling qualities. Sown at the rate of one-half bushel per acre it produced 31.3 bushels per acre, although better yields were secured with six pecks per acre. (See page 49.) The advantage in sowing such a wheat is that a poor stand may be largely compensated by this special capacity for stooling.

2. Cultural Directions.

Kentucky produced in 1910, 9,600,000 bushels of wheat on 750,000 acres, an average yield of 12.8 bushels per acre. This is the highest average yield per acre in ten years, with the exception of 1906, when it was 14.1 bushels. The average yield for the decade 1901 to 1910 was 11.5 bushels per acre. The average yield for the United States for this decade was 14.3 bushels. Kentucky produces hardly 2.1 per cent of the wheat grown in the United States.

Taking 90 cents per bushel as the average farm price for wheat, the gross income per acre for Kentucky for the last ten years has been $10.35. It does not require any argument or additional statistics to convince one that wheat is produced at a loss in this State as a whole. When the cost of labor, machinery, fertilizers, taxes, rent on the land and other expenses are deducted, where is the farmer's profit? Incidentally it may be said that the showing for other grain crops and the hay crops is little better.

There are some of the more fertile sections of the State in which wheat can be made a profitable money crop, provided good methods are employed in growing it. Nowhere should it be grown except in rotations. In the less fertile and rougher sections, such as the Eastern and Southeastern parts of the State, it is the writer's judgment that there should be no attempt to raise wheat for the markets, but that persons engaged in general farming should raise sufficient wheat, in proper rotations, to afford breadstuff for the family, provided, of course, that there are threshing and milling facilities.

The chief reasons for the low production of wheat in the State are:

1. The use of poor seed.
2. The failure to properly prepare the soil.
3. The impoverished condition of the soil.

Ths Seed.

Different varieties and strains of wheat differ in their producing capacity, in the quality of the grain, and in the character of the straw. The first consideration is to get a wheat adapted to the locality in which it is to be grown, that is, it must yield well, have a grain of good milling quality, and a straw that will not lodge. There is but one practical way to determine this, and that is to obtain promising varieties, and try them out on plots of the same size located on soil uniform in fertility and other characteristics. When the wheat is threshed, weigh it carefully and get an experienced miller to pass his judgment upon its quality. The

Experiment Station has been unable to carry on variety tests on the various soil types of the State, because of lack of funds.

In selecting new varieties or strains of wheat, they should be gotten from localities as nearly like the one in which they are to be grown as is possible. The fact that a variety of wheat yields well in one part of the country, does not mean that it will yield well in another. For example, Dawson's Golden Chaff is one of the most productive varieties grown in Canada and the Northern part of the United States. In a variety test at this Station it was tried for four years and ranked thirty-second out of forty-one varieties, with an average weight per bushel of 55.2 pounds and an average milling quality of 85.7 per cent. The Illinois Station found Dawson's Golden Chaff to be the third in yield among seventeen varieties when tried out in Northern Illinois, but when tried in Southern Illinois, it was eleventh in yield among eighteen varieties, and was so unproductive that it was discarded. The Illinois Station* found home-grown Harvest King to be second highest yielder for Southern Illinois, and to outyield strains of Harvest King imported from Indiana and Michigan.

The results of experiments at the Experiment Stations of Illinois, Indiana, North Dakota, Nebraska and Maryland indicate that home-grown seed produces better results than seed of the same varieties obtained from a distance. In Bulletin No. 121 of the Illinois Station, after citing numerous references to experiments, the authors make this statement:

"There seems to be no adequate evidence to show that the practical wheat grower can hope for any gain from changing seed wheat merely for the sake of changing. There is more likelihood of loss by a change than of making any practical gains."

While we have no data at the Kentucky Station to support this statement, the weight of evidence from other Stations leads us to believe that it is sound. It is our opinion that the best place to buy seed wheat is *at home*, if it can be found

*Bulletin No. 121, Illinois Experiment Station.

there; if not, then at a place as *nearly like home as possible.* Wheat does not "run out" as is popularly believed. It is generally the farmer who "runs out" by failure to properly clean his wheat, by failure to keep up the fertility of his soil, and by failure to properly prepare the seed bed.

What, then, is the basis for the belief that a change of seed wheat gives better results than the use of home-grown seed? As a rule the Kentucky farmer sows his home-grown seed without properly screening it, on poorly prepared ground of the average fertility of his farm. Seed wheat bought away from home usually comes well screened. The seed grower cannot afford to send out any other kind of seed. The farmer pays a good price for the seed and thinks (rightly) that he must give it a good chance. He usually sows it on the best ground on the farm, which is given extraordinary preparation. If he had followed the practice of selecting his home-grown seed as carefully as the grower of his imported seed had done, and had planted it on the same kind of soil with the same preparation, the chances are that he would have obtained as good results from his home-grown seed.

The importance of sowing good seed was well illustrated on the Experiment Station farm with the 1911 crop. There were two grades of Harvest King wheat on the farm in 1910. One was well screened plump seed. The other was wheat that had been slightly damaged in the shock, was not well screened and was not intended for seed purposes. Part of a field was sown with the poor seed, and part with the good. The yield of the better seed was 29.5 bushels per acre, and of the poorer seed, 26.3 bushels per acre, a difference of 3.2 bushels per acre.

As an illustration of the value of sowing home-grown seed, the Illinois Station found on a three-year test that home-grown Harvest King seed produced 1.8 bushels more per acre than Harvest King seed imported from Indiana, and 2.9 bushels per acre more than seed of that variety imported from Michigan.

Once a farmer has secured a high yielding wheat of good quality, he should keep it pure and continue to improve it. This may be done by setting aside a block each year for seed purposes. The seed block should be allowed to ripen well and should have extra attention to prevent its becoming damaged in any way. The seed for the general field should be well screened wheat from this block, and the seed for the seed block should have extraordinary attention in the matter of screening. Wheat does not cross pollinate as corn does, but grains from other wheat may get mixed in from the thresher and render seed impure. Care should be exercised to clean out the thresher before starting on the seed block. One could well afford to go over the seed block and cut out the foreign heads.

It is possible for the observant farmer to improve his wheat crop through breeding by selection. Some of our most productive varieties of wheat have been produced by farmers without any special scientific training in plant breeding. For example, Fultz, a red grained beardless variety, originated by the selection of heads of this description that appeared as a variation in a field of Lancaster, a red bearded variety. These selections were made in 1862 by Abraham Fultz, Mifflin County, Penn.

The writer heard Professor C. A. Zavitz, of the Ontario Agricultural College, give an account of the origin of Dawson's Golden Chaff. He said that it evidently started from a sport, that is a striking variation, such as is liable to occur in any wheat field. Mr. Robert Dawson, of Paris, Ontario, had a field of White Clawson wheat in 1881, which lodged badly. While walking through the field he found one plant standing erect, possessing a much stiffer straw than the surrounding wheat, and of a different type. He saved the plant and sowed the seed the next year. Finally a sample of the wheat was sent to the Ontario Agricultural College, where it was tested along with other varieties and found to possess the stiffest straw and to give the largest yield of grain. This is the simple origin of a

variety grown to a very large extent in Canada and the Northern part of the United States.

Numerous other instances could be cited showing similar origin of varieties of wheat. Such variations are apt to occur in any wheat field, and the farmer of an observant nature can easily make such selections and propagate them. As wheat does not cross fertilize, so there is no necessity for keeping selections isolated. A number of selections may be tried out side by side.

Improvement by selection may be made without waiting to find the striking variations, called sports. Fine large heads of good quality and high producing capacity may be selected from any field of wheat and propagated until sufficient seed is produced for general use.

It is not within the province of this Bulletin to take up the question of breeding in detail. but these suggestions are given to call attention of thoughtful farmers to the possibilities for the improvement of their wheat.

Preparation of the Soil and Seeding.

The low yield of wheat in Kentucky is no doubt due much more to the poor preparation of the seed bed than to inferior seed. It is generally believed throughout the State that wheat yields much better following tobacco than when following any other crop, and that tobacco is responsible for the increased yield. The evidence is not of a conclusive nature. There is no doubt that our best yields of wheat are gotten from tobacco fields. But consider the tobacco field and the treatment it has received. The tobacco field is the most fertile piece of ground on the farm. It is well prepared, for tobacco is the money crop of the farm. It is well cultivated and kept free from weeds. Tobacco probably does not require the amount of moisture that the corn crop does, (wheat in this State usually follows corn), while the presence of more weeds in the corn field than in the tobacco field robs the soil of additional moisture and plant food. The careful preparation of the tobacco field conserves moisture and develops more available plant food than is developed in the corn

field, which is not so fertile, as a rule. Contrary to the general belief, a crop of tobacco does not take as much plant food from the soil as a crop of corn which the same soil is capable of producing. Soil which will produce 1,500 pounds of tobacco per acre should produce 75 bushels of corn per acre. The tobacco contains approximately 48 pounds nitrogen, 12 pounds phosphoric acid and 66 pounds potash, while the corn, includlng the stover, contains approximately 111 pounds nitrogen, 40 pounds phosphoric acid and 64 pounds potash. It is therefore evident that tobacco land is in much better physical condition and contains more moisture and available plant food than the corn land. It is moisture and available plant food that the wheat crop needs to start it off in the fall. Moreover, it is impossible to put the soil of the corn field in good condition for wheat on account of the interference of the stalks, and besides there is a great waste of space in the ground occupied by the corn shocks in case the corn is cut. Again, there is more or less injury to the wheat by the gathering of the corn and stover. The tobacco land is easily put in ideal condition for wheat.

To obtain the best results, it is our belief that wheat should not follow corn in any rotation, for the reasons enumerated above. The Experiment Station has adopted a rotation of corn followed by rye for a winter cover crop, which is turned under in the spring when the ground is prepared for soy beans (or cowpeas) for the second year crop. Soy beans are followed by wheat for the third year, and wheat by clover for the fourth year. This rotation gives a clover sod for corn, and allows a green crop of rye to be turned under. The rye prevents the loss of available plant food left in the corn field and prevents washing during the winter. The soy beans leave the ground in as fine condition for wheat as tobacco, and being a legume, do not draw so heavily upon the soil nitrogen as tobacco. Thus in this rotation there is the advantage of one rye cover crop and two legume crops in four years. In a corn, wheat and clover rotation there is no cover crop to be turned under, and only one legume crop. The experience on the Experiment Station

farm is that the yield of wheat is just as good after soy beans as after tobacco, the yield running from 30 to 40 bushels per acre in favorable seasons.

It may be objected that one would not want to cultivate so much land in soy beans or cowpeas as in corn and wheat. At present there is great demand for soy bean and cowpea seed. One-half of the field could be sown in soy beans for hay and the other half drilled in rows and cultivated for seed. The seed of cowpeas and soy beans usually retail for $2.50 to $3.00 per bushel. A farmer producing the seed could build up a profitable trade in selling direct to the consumer. If it were not desired to sow the whole field to beans, one-half could be sown to oats and the other half to beans. The oats would come off in time to give the ground good preparation for wheat. At the next turn of the rotation, put oats where the beans were grown in the previous turn, with beans where the oats were. The point of this discussion of the rotation is to avoid sowing wheat in corn land, a practice which, in our judgment, is largely responsible for our low yield of wheat.

What constitutes a good seed bed for wheat? *The soil must be thoroughly pulverized, well compacted, and have a good contact with the subsoil.* It is impossible for the crop to get the maximum supply of moisture and plant food from a soil that is not finely divided. The plant gets its moisture, and therefore its food, which is in solution in the soil moisture, only by the root hairs of the plant coming in direct contact with the soil grains. The moisture exists in films around the soil grains, just as a film of moisture adheres to a marble that has been immersed in water and removed from it. The crop must obviously fail to utilize the moisture and plant food in clods and other parts of the seed bed that the roots cannot penetrate.

The compacting of the seed bed brings the soil particles closer together and allows the moisture to rise more freely from the subsoil into the seed bed where the roots of the young plant can reach it. It is when the wheat is first sown that it most needs moisture and is least apt to get it. The

ideal seed bed is one finely divided and well compacted, as stated, with about an inch of loose dirt on top, so that when the seed is drilled it will lie on a firm bed, covered by loose soil. This kind of a seed bed is necessary for all small seed, for the reason that small seed cannot come in contact with sufficient moisture in a loose rough seed bed; besides, such a seed bed soon dries out. Small seed are sown shallow, and stand very great chances not to rest on a firm stratum of soil that will bring them sufficient moisture. This condition explains, in our judgment, so many failures to get a stand of the small seed crops.

The seed bed must have a good contact with the subsoil for the reason that it must be largely supplied with moisture from the subsoil. The soil water rises through the soil by capillary attraction just as oil rises in the wick of a lamp. It is evident that if clods are turned under in the preparation of the seed bed, there will be spaces that will prevent the rise of water from the subsoil. Dry weeds and stubble will produce the same result.

The methods to be pursued and the implements to be used to produce such a seed bed as has been described will depend upon the nature of the soil to be prepared. Many different implements may be used to accomplish the same result. Some of them are of course more effective and economical than others.

If the ground to be sown to wheat needs only to be disked, such as tobacco, corn, soy bean, or cowpea ground, this operation should be performed as soon as possible after the crop is removed, and should be thoroughly done. If necessary to disk more than once, double disk back and forth rather than round the field or in large lands, and then cross at right angles in the same way. A spike tooth harrow may complete the operation. It may require the use of a heavy drag, which is much more efficient than a roller for crushing clods. Preparation should not cease until the seed bed is good enough to plant a garden in. More horse power should be used in the preparation of the soil. Four horses hitched to a disk harrow or to a drag, well weighted down, will

accomplish more than twice as much work as two horses. When the seed bed is once gotten in good condition, it should be harrowed frequently until seeding time. Especially should this be done as soon after rains as possible, in order to break the crust and conserve the moisture. These frequent harrowings will also kill out weeds and help to develop available plant food.

If the land has to be turned for wheat, this should also be done early, say in July or early August, in order that it may settle sufficiently for a good seed bed. Before turning, it should be thoroughly disked until the surface is in a finely divided condition. This will prevent loss of moisture until the ground can be gone over with the turning plow, and the finely divided soil will make a good contact with the subsoil, thus allowing the rise of moisture. Each day's plowing should be harrowed at the close of the day to prevent the formation of hard clods by drying. It would be better if the harrowing were done both noon and night. After the ground has been plowed in this way, it should be given the treatment until seeding time indicated for the disked ground. Ground thus prepared will give an increased yield that will justify the cost, and will soon get in such condition that it will be easy to prepare. The practice indicated will hold in the preparation of any seed bed, except of course that fall and winter plowed land for spring planting should not be harrowed but left rough to prevent washing and to facilitate the absorption of water.

Immediately before sowing wheat the ground should be harrowed and rolled with a heavy roller. This will firm the seed bed and make moisture conditions better around the seed.

A drill should be used which will deposit the seed on the bottom of the furrows opened by the drill. It is very undesirable that the seed be caught by the closing furrow before it has reached the bottom. The advantage of having the seed rest on the bottom of the furrow is that it rests on a firm bed and therefore gets more moisture and a better medium in which to develop its roots.

The depth of seeding depends on conditions. If the seed bed is properly prepared, one inch of moist soil on seed resting on a firm seed bed would be sufficient. Seed may be planted deeper in sandy soil than in clay soil. The season should have something to do with the depth, the drier the season the deeper the planting may be. In a cloddy seed bed it is necessary to get some of the seed too deep in order to get all deep enough. No definite rule for depth can be given, but an average of one and one-half inches is not far from right. In no soil should the planting be more than three inches or less than one inch.

Wheat should not be sown earlier in Kentucky than the first of October, because if sown earlier it is liable to suffer depredations of the Hessian fly. From the first to the tenth of October seems to be the best time in the vicinity of Lexington.

Our experiments for two years on the rate of seeding seem to indicate that 6 pecks per acre produce the best results. However, not enough work has been done that much importance can be attached to the results. All the variety tests and general fields at the Station are seeded at the rate of 6 pecks per acre. The following tables gives the results with Harvest King and Miracle:

HARVEST KING

Amount Sown Per Acre	Yield, Bu. per A.		
	1910	1911	Average
4 pecks	28.0	35.0	31.5
5 pecks	25.3	35.0	30.1
6 pecks	35 1	34.7	34.9
7 pecks	28.5	36.3	32.4
8 pecks	32.1	25.0	28.5

MIRACLE

Amount Sown Per Acre	Yield 1911 Bu. per A.
2 pecks	31.3
3 pecks	32.7
4 pecks	34.7
5 pecks	35.3
6 pecks	36.7

The party furnishing Miracle recommended two pecks per acre, claiming great stooling power for it.

Fertilizers For Wheat

The Experiment Station receives many letters asking what is the best fertilizer for wheat. There is no best fertilizer for wheat. What would produce good results on one type of soil might fail to give any results at all on other soils. There is only one safe rule, so far as fertility is concerned, for producing good crops of any kind, and that is to keep up the fertility of the soil by a judicious rotation of crops, the use of all the manure that can be produced on the farm, and the purchase of whatever mineral elements of plant food the soil may be deficient in. For example, the soil in the central Blue Grass counties is rich in phosphorus, and the use of phosphate on such lands, when in good condition, does not give profitable results. But most of the lands of the State outside of this region are deficient in phosphorus and the use of phosphatic fertilizers usually gives good results. Practically all soils of the State contain sufficient potassium, with perhaps the exception of the Blue Grass region, and it is, as a rule, not necessary to buy this element of plant food. It must be remembered, though, that in order to render the mineral elements of plant food in the soil available, a good supply of organic matter must be kept up, the decay of which renders them available.

Any soil may soon be rendered deficient in nitrogen for the reason that the nitrogen of the soil is contained in the organic matter which is easily destroyed by cultivation. The supply of nitrogen can be kept up profitably only by keeping a generous supply of organic matter in the soil.

The usual practice in fertilizing wheat in this State is to use 200 pounds or less (usually less) of a complete fertilizer containing approximately 8 per cent of phosphoric acid, 1.65 per cent of nitrogen and 2 per cent of potash. This would give 16 pounds phosphoric acid, 3.3 pounds nitrogen and 4 pounds of potash per acre, whereas a thirty-bushel wheat crop, including the straw, removes from the soil approxi-

mately 22 pounds of phosphoric acid, 57 pounds of nitrogen and 35 pounds of potash. It is evident that the nitrogen supply cannot be kept up by the use of fertilizers of this description. To buy sufficient nitrogen to meet the requirements of the crop would render it unprofitable.

The solution of the problem of fertility, then, is, as stated, to keep up a good humus supply by a good rotation containing clover and other legumes and by the use of manure, supplemented by the purchase, in sufficient quantity, of the element which may be deficient, which is usually phosphorous. It is no doubt profitable, on many soils, to use a high grade complete fertilizer to give the crop a good start, but it should always be borne in mind that the use of it alone will not keep up the fertility of the soil.

Any soil, no matter how abundantly supplied with the mineral elements of plant food, may become so deficient in organic matter that the availability of the mineral plant food will not be sufficient to meet the needs of the crop. In such cases the use of commercial fertilizers may give profitable results, and may be used until a supply of organic matter is restored to the soil.

(For a further discussion of the use of fertilizers see Bulletin No. 140.)

Aside from the fertilizing value of humus it has other important functions. Humus increases the *capacity* of the soil to hold water and increases its ability to *retain* water. These are important considerations in the growing of the wheat crop, because wheat requires a large amount of water, and the soil cannot be cultivated successfully to retain it.

A good humus content prevents to a large degree the "freezing out" of wheat. Two years ago there was much complaint of winter killing of wheat. The writer made limited observations of wheat fields and found invariably that where the wheat was frozen out there was a low humus content. In looking over one large field, there were numerous spots where the wheat was good, while in other places it was frozen out. The good places were well supplied with humus, while the poor places were deficient. This field was

about five miles from the Experiment Station farm, on which the wheat was never better than that year. When soil is devoid of humus the soil grains run together, forming a hard, compacted soil. When soil in this condition is filled with water and freezes, the only release for the consequent expansion is upward, and this of course causes "lifting" of the wheat. If the soil is well supplied with humus, it has what is called crumb structure, which gives it much greater pore space, consequently upon freezing there is room for lateral movement of the soil upon expansion and the wheat does not life, as in the other case.

3. Treatment of Diseases.

There is never a year when one or more of the diseases which attack the wheat plant do not, in some sections, materially reduce the yield of grain. Rust may in certain seasons seriously affect the crop. Wheat scab shows up occasionally, and while the loss from this disease is usually light, it may reach as high as 10 per cent. In 1909 scab was very prevalent in Kentucky and most certainly reduced the yield in many fields 10 per cent. In addition to these two diseases, the smuts annually cause considerable loss in the State. Other less destructive diseases attack the growing wheat and exert their influence in reducing the yield, but they are not nearly so important or destructive as the ones mentioned.

These diseases are all due to the growth of parasitic fungi within the tissues of the wheat plant. These fungi are slender colorless plants, although the masses of spores may be colored, as the black smut spores and the reddish rust spores. They appropriate the nourishment which normally would go to increase the vigor of the wheat plant and make plump, perfect grains of wheat. They reproduce by means of spores, which are very minute objects, the individual spore being plainly discernible only under a strong microscope. These spores correspond to seeds in the higher plants. The life histories of some of

these fungi are quite complicated, and need not be discussed in detail here. The one important thing to remember in regard to all these fungi is, that wherever present they reduce the yield of grain to a greater or less extent.

Wheat Rust.

Wheat rust undoubtedly causes more damage to the wheat crop than any other disease, and in seasons favorable to its growth and spread, may result in decreasing the yield of grain 50 per cent. Every farmer is familiar with rust of wheat, and knows the climatic conditions under which it thrives, viz., hot, moist, showery weather during the period of maturity of the wheat, followed by cooler moist weather. Although the disease has been known and studied for a long period of time, no really effective remedy has been found. Encouraging early maturity of the crop by having the soil in good condition, and with plenty of plant food in it; sowing as early as may be safely done to avoid the fly, and having a thick uniform stand of plants, will do much to reduce the ravages of this disease.

It is also true that some of the common varieties of wheat are more resistant to rust than others. Usually stiff, hard strawed varieties are less susceptible to its attacks than the weak, soft strawed varieties, and this fact may be taken advantage of in efforts to reduce the losses from its presence. In this connection it may be said that efforts are being made to breed up varieties of wheat that are practically rust resistant, and that the outlook is fairly encouraging.

Wheat Scab.

Wheat scab is a fungus disease attacking the glumes or chaff of wheat, causing the grains to be shrunken and worthless. It is easily identified by the dead glumes, frequently only a few on each head being affected, and by a pinkish incrustation at the base of the affected glumes. It is also dependent on climatic conditions, and only occasionally is abundant enough to cause much loss. There is no known remedy.

Smuts of Wheat.

There are two smuts affecting wheat, the loose smut, when the affected heads are commonly spoken of as "blasted" heads, and the stinking smut. The former is the more common, and the latter by far the more destructive.

Stinking Smut.

The life histories of these two smuts are quite similar up to a certain stage. In the case of the stinking smut the spores cling to the outside of the sound wheat grains and when the wheat is planted and germinates, the spores germinate and send out slender colorless threads. These threads find entrance into the young plant by growing into the sprout, and as the plant grows the threads increase and branch, and are always to be found in the growing part of the plant. When the wheat heads out in preparation for seed production, the smut threads occupy the head or spike, rapidly increase and finally break up into small pieces, each piece forming a spore. The masses of these spores occupy the space normally occupied by the wheat grains, and as the chaff is not affected, it is not easy, unless the head is closely examined, to detect the smut. Upon close examination, however, the head will be noticed to be light and to keep an upright position. The chaff has a peculiar appearance, being looser and more spread out. If any quantity is present the odor coming from the field always tells of its presence. The covering of the smut masses is quite firm and these masses have a shape and size not unlike grains of wheat, but are shorter and more blunt. They crush easily and in threshing are broken up and the sound wheat becomes covered by the spores; then when the wheat is planted, the spores are ready to germinate and infest the young wheat plant.

Besides the direct loss due to the smutted heads, which may be very considerable, the strong, disagreeable odor of the smut is imparted to the wheat, rendering it unfit for milling until thoroughly cleaned and scoured. This extra

work is always charged to the producer in the shape of a lower price for his grain.

Loose Smut.

The life history of the loose smut is very similar to that of the stinking smut, except that it matures much earlier, in fact very shortly after the grain is headed. The chaff and grain space are entirely occupied by the smut spores which mature when the wheat is in bloom and a loose, black, powdery mass of spores is produced. The spores are carried by the wind to the unaffected heads and, it is supposed, find their way inside the chaff to the immature grains, where they germinate and the tiny threads grow into the germs of the grain. As the wheat matures these tiny smut plants are present in the embryo, and when the grain is planted enter the young wheat plant as in the case of the stinking smut.

The essential difference to be noted in these two smuts is the position of the pores and smut plants in relation to the mature grain, the spores of the stinking smut being on the surface of the grains, where they may be easily destroyed, while the spores of the loose smut have already germinated and produced tiny smut plants which are enclosed in the grain, where they are with difficulty destroyed.

Treatment of Stinking Smut.

Every farmer should treat his seed wheat for stinking smut if any at all was present in his crop, or even if any of his neighbors' crops were affected. The spores are easily carried by the traveling threshing machine in sufficient numbers from infested wheat to affect wheat which may be threshed by the same machine. At the Experiment Station stinking smut has not been present for many years, a fact which may be due to the Station having always owned and operated its own separator.

There are several methods of treating wheat for stinking smut, all easily and cheaply applied, and the results are sure if the work is carefully done. The chief methods and the manner of their application are given below:

Formalin Treatment.

This is applied in two ways, dipping and sprinkling, the latter being perhaps more rapid and convenient. The smut balls are either blown out with a good fanning mill, or the wheat immersed in water and thoroughly stirred, when the light smut balls will come to the surface of the water and can be skimmed off. This feature is very important.

A solution is made by pouring a pint of formalin into 40 to 50 gallons of water and thoroughly stirring. The formalin must be full strength 40 per cent solution of formaldehyde, and only that guaranteed to be this strength should be used. If the grain is to be dipped, about a half bushel should be put in each sack, so that the sacks may be easily handled. The sack of wheat is immersed in this solution and kept there ten to fifteen minutes or until all the wheat is thoroughly wet. The surplus solution is then partly drained off into the barrels and set aside for five to ten hours or even longer. The grain is then spread out to dry sufficiently to sow, or completely dried, when it may be stored and kept any length of time.

In sprinkling with the formalin solution, the wheat is put in a pile and the solution sprinkled on the wheat with a sprinkling can, the wheat being shoveled over until it is thoroughly wet. It should then be piled up and covered with wet sacks or a tarpaulin for say five to ten hours, or longer will do no harm, when it should be dried sufficiently to sow, or completely dried and stored in a clean place. The drying can be accomplished rapidly by spreading out thinly and stirring frequently. A gallon of the solution will treat a bushel of grain.

The formalin treatment is cheap and convenient, and the solution pleasant to handle. There is less liability of injuring the grain than with other treatments, even if the operator is somewhat careless. In a large number of tests made by the agricultural students last winter, using various strengths of solutions, less injury resulted from this treatment than from any others. Even when the grain was left in the solution an hour or more, no injury resulted.

Blue Stone Treatment.

The blue stone treatment is the most widely used in Kentucky, in some sections practically all the farmers treating their seed by this method.

Ten pounds of blue stone are dissolved in boiling water, and enough water added to make 40 to 50 gallons of the solution. If only a small quantity of wheat is to be treated a smaller amount of the solution may be made, keeping the proportions the same. Either the dipping or sprinkling method may be employed, as in the case of the formalin treatment. If dipped, the seed should remain in the solution only long enough to become thoroughly wet. This will take from five to ten minutes, according to the amount of grain in the sacks. The surplus solution should then be drained off into the barrel, and the wheat spread out so it can more thoroughly drain. In sprinkling only enough solution should be applied to thoroughly moisten the grain, and opportunity should be given for any surplus that may be used to drain off. Most of the injury from treating with blue stone is due to allowing too much of the solution to soak into the grain. If the seed is to be sown at once it need not be perfectly dry, but allowance must be made for the swollen grain in sowing the desired quantity per acre. If not to be used at once, it must be thoroughly dried, when it may be stored in a clean place and kept indefinitely. About a gallon of the solution is required to treat a bushel of grain. Some authorities advocate dipping the wheat in lime water after treatment, but if care is taken as to the strength of the blue stone solution and the grain carefully drained, this is not thought to be necessary.

Hot Water Treatment.

This is one of the old reliable methods of treatment and is thoroughly effective. The cost outside of the labor is practically nothing. However, considerable care must be observed in its application, and the method is not as rapid as either of the others. For this reason it is not liable ever to

become very popular with the farmers of the State. The treatment is based upon the fact that the wheat grain can be exposed to a heat sufficient to destroy the smut spores clinging to it without injuring the grain itself. This can be done in a practical way only by the use of hot water.

It is necessary to have the following equipment for the work: A large kettle to heat water in; two barrels, tanks, or similar receptacles; a number of buckets; a long paddle for stirring, and most important, a reliable, tested thermometer. A convenient supply of cold water must also be ready. The two barrels are to contain hot water, one water of a temperature of about 125° F. and the other water of a temperature of 130° F. to 135° F. This latter temperature is that at which the spores are destroyed. If the cold wheat were dipped directly into this barrel the temperature of the water would be greatly lowered and some time required to bring it back to the required temperature, hence the other barrel of water at 125°. The wheat, which is put into loose sacks or close wire-lined baskets containing not more than ½ bushel each, is dipped first into the barrel with water at 125° and kept there a short time until the wheat is warmed up to a temperature approaching that of the water in the second barrel (130° to 135° F.) It is then quickly transferred to the second barrel in which the temperature should be kept uniform by the addition of very hot or cold water as conditions require. The temperature must not fall below 130° F. or the smut spores will not be killed, nor should it rise above 140° F. or the grain will be injured.

When adding hot water, do not pour directly upon the grain, and the water should be stirred frequently so as to be uniform in temperature throughout the barrel. The wheat is kept here for ten or fifteen minutes and then emptied out, spread in a thin layer, and shoveled over until sufficiently dry to sow if it is to be sown at once, or it may be thoroughly dried, when it can be stored and left for several weeks or even months. If sown before dry, the increased size of the grain requires allowance in sowing as stated under the blue stone treatment.

An ingenious man could probably devise some system by which the water could be heated and kept near the required temperature in the two tanks, thus doing away with the kettle to boil water in and handling the hot water. Of course metal tanks similar to watering tanks would be necessary. Large kerosene heaters might be employed to heat the water.

In this treatment it is of great importance that the temperatures be maintained as closely as possible to those given, or the grain may be greatly injured.

In all treatments for stinking smut care must be taken that the seed does not become infested again by coming in contact with infested bins, floors, sacks or seeders. The only safe way is to spray or scrub bins, floors and seeders with a strong solution of formalin (1 pint to 5 gallons of water). Sacks and canvas may be dipped in boiling water to cleanse them.

Treatment for Loose Smut

The treatment for loose smut is necessarily much more drastic than for stinking smut, because, as stated before, the spores have already germinated and the smut plants are inside the wheat grain and difficult to destroy. There is only one treatment which will accomplish this, the so-called Jensen's modified hot water treatment. It is described in Bulletin 152 of the Bureau of Plant Industry of the U. S. Department of Agriculture, to which Bulletin the reader is referred for detailed description of the method. In brief, the method is as follows: The seed is carefully cleaned and then soaked in cold water for from five to ten hours. This causes the heat to penetrate more quickly when the wheat is immersed in the hot water. The same methods are then pursued as given under the hot water treatment for stinking smut. It is recommended in the bulletin referred to that the water in the first barrel be kept at 128° F. and in the second at 129.2° F. The sacks or baskets used must not contain more than a peck of the

grain. After draining off the cold water, the grain is immersed in the first barrel for about a minute and then qnickly transferred to the second, where it should remain exactly ten minutes. The temperature should be kept very close to the required degrees by the addition of hot or cold water. Great care and exactness must be exercised in this treatment or the wheat will be badly injured. The wheat after treatment is spread out and stirred until dry enough to sow, or perfectly dried out and stored. Drying is affected by spreading in a thin layer and stirring frequently. If sown while damp, due allowance must be made for the swollen condition of the seed. This applies, however, whatever the treatment, whether for loose or stinking smut.

The seed should be tested for germination after treatment, and if the germination is low, a sufficient amount of seed should be planted in addition to the usual quantity to insure a stand.

This treatment is rather slow and expensive, and it is not recommended to treat the seed for the entire crop by this method. It should be used in connection with the seed block referred to earlier in this bulletin.